Tennessee Valley Authority, Post Office Box 2000, Soddy Daisy, Tennessee 37384-2000

May 1, 2015

10 CFR 50.73

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Unit 2
Facility Operating License No. DPR-79
NRC Docket No. 50-328

Subject: **Licensee Event Report 50-328/2015-001-00, "Automatic Reactor Trip due to Failure of Main Generator C-phase Neutral Current Transformer Cable"**

The enclosed Licensee Event Report provides details concerning an automatic reactor trip following a turbine trip. The event was due to the failure of the main generator C-phase neutral current transformer cable. This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(iv)(A), as an event that resulted in a manual or automatic actuation of the Reactor Protection System and the Auxiliary Feedwater System. This condition had no impact on Unit 1.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this submittal, please contact Ms. Erin Henderson, Sequoyah Site Licensing Manager, at (423) 843-7170.

Respectfully,

John T. Carlin
Site Vice President
Sequoyah Nuclear Plant

Enclosure: Licensee Event Report 50-328/2015-001
cc: NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant

IE22
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NRC FORM 366 (02-2014) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 01/31/2017

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA, Privacy and Information Collections Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

# LICENSEE EVENT REPORT (LER)

(See Page 2 for required number of digits/characters for each block)

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**4. TITLE**

Automatic Reactor Trip due to Failure of Main Generator C-phase Neutral Current Transformer Cable

| 5. EVENT DATE | | | 6. LER NUMBER | | | 7. REPORT DATE | | | 8. OTHER FACILITIES INVOLVED | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REV NO. | MONTH | DAY | YEAR | FACILITY NAME | DOCKET NUMBER |
| 03 | 02 | 2015 | 2015 | - 001 | - 00 | 05 | 01 | 2015 | FACILITY NAME | DOCKET NUMBER |

| 9. OPERATING MODE | 11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)* | | | |
|---|---|---|---|---|
| 1 | ☐ 20.2201(b) | ☐ 20.2203(a)(3)(i) | ☐ 50.73(a)(2)(i)(C) | ☐ 50.73(a)(2)(vii) |
| | ☐ 20.2201(d) | ☐ 20.2203(a)(3)(ii) | ☐ 50.73(a)(2)(ii)(A) | ☐ 50.73(a)(2)(viii)(A) |
| | ☐ 20.2203(a)(1) | ☐ 20.2203(a)(4) | ☐ 50.73(a)(2)(ii)(B) | ☐ 50.73(a)(2)(viii)(B) |
| | ☐ 20.2203(a)(2)(i) | ☐ 50.36(c)(1)(i)(A) | ☐ 50.73(a)(2)(iii) | ☐ 50.73(a)(2)(ix)(A) |
| **10. POWER LEVEL** | ☐ 20.2203(a)(2)(ii) | ☐ 50.36(c)(1)(ii)(A) | ☒ 50.73(a)(2)(iv)(A) | ☐ 50.73(a)(2)(x) |
| | ☐ 20.2203(a)(2)(iii) | ☐ 50.36(c)(2) | ☐ 50.73(a)(2)(v)(A) | ☐ 73.71(a)(4) |
| 100 | ☐ 20.2203(a)(2)(iv) | ☐ 50.46(a)(3)(ii) | ☐ 50.73(a)(2)(v)(B) | ☐ 73.71(a)(5) |
| | ☐ 20.2203(a)(2)(v) | ☐ 50.73(a)(2)(i)(A) | ☐ 50.73(a)(2)(v)(C) | ☐ OTHER |
| | ☐ 20.2203(a)(2)(vi) | ☐ 50.73(a)(2)(i)(B) | ☐ 50.73(a)(2)(v)(D) | Specify in Abstract below or in NRC Form 366A |

**12. LICENSEE CONTACT FOR THIS LER**

| LICENSEE CONTACT | TELEPHONE NUMBER *(Include Area Code)* |
|---|---|
| Rebecca L. Travis | 423-843-8335 |

**13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT**

| CAUSE | SYSTEM | COMPONENT | MANU-FACTURER | REPORTABLE TO EPIX | CAUSE | SYSTEM | COMPONENT | MANU-FACTURER | REPORTABLE TO EPIX |
|---|---|---|---|---|---|---|---|---|---|
| D | EL | CBL | W120 | Y | | | | | |

| 14. SUPPLEMENTAL REPORT EXPECTED | 15. EXPECTED SUBMISSION DATE | MONTH | DAY | YEAR |
|---|---|---|---|---|
| ☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO | | | | |


ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On March 2, 2015, at 0645 Eastern Standard Time, Sequoyah Nuclear Plant (SQN) Unit 2 reactor automatically tripped following a turbine trip due to actuation of the main generator 287G differential relay. The relay actuation was a result of a failure of the main generator C-phase neutral current transformer (CT) cable. All safety related equipment operated as designed, all control rods fully inserted as required, and auxiliary feedwater automatically initiated from the feedwater isolation signal as expected. A broken splice connection was identified between the 287G differential relay and the C-phase CT. This main generator C-phase neutral CT cable failed open due to a combination of corrosion and periodic physical manipulation. The cause of this event was a lack of inspections in the preventive maintenance (PM) procedure to identify potential failure mechanisms. Prior to restart, both Unit 2 C-phase neutral CTs and one B-phase neutral CT along with all associated neutral side field cables were replaced. Corrective actions to prevent recurrence include replacement of all Unit 1 and Unit 2 main generator CT bolted connections with solder filled splices, covered in Raychem to prevent water intrusion. The condition described in this LER did not have an impact to SQN Unit 1.

**NARRATIVE**

## I. PLANT OPERATING CONDITIONS BEFORE THE EVENT

At the time of the event, Sequoyah Nuclear Plant (SQN) Unit 1 and Unit 2 reactors were operating at approximately 100 percent rated thermal power. The condition described in this LER did not have an impact to SQN Unit 1.

## II. DESCRIPTION OF EVENTS

### A. Event:

On March 2, 2015, at 0645 Eastern Standard Time (EST), SQN Unit 2 reactor automatically tripped following a turbine trip due to actuation of the 287G Generator 2 Differential Relay [EIIS Code 87].

Continuity tests performed for the 287G current transformers (CTs) [EIIS Code XCT] found the C-phase to have an open circuit. A walk down of the related equipment identified an open cable in the main generator C-phase neutral CT junction box. The relay actuation was a result of this open circuit.

All safety related equipment operated as designed, all control rods fully inserted as required, and auxiliary feedwater automatically initiated from the feedwater isolation signal as expected. No complications were experienced during the reactor trip.

### B. Status of structures, components, or systems that were inoperable at the start of the event and contributed to the event:

There were no structures, components, or systems that were inoperable at the start of the event.

### C. Dates and approximate times of occurrences:

On May 4, 1992, new field cables were routed and new terminations to manufacturer field cables were installed. Bolted connections were utilized in contradiction to the CT vendor manual recommendation of soldered and taped joints. On May 12, 2003, a preventive maintenance change request (PMCR) was initiated to revise the preventive maintenance (PM) procedure to add inspection of the CT junction box and connections. This PM is for inspection and cleaning of the turbogenerator protective electrical circuits.

On November 23, 2003, Watts Bar Nuclear Plant (WBN) identified an issue involving flexible conduit assemblies loosening due to vibration and physically becoming detached from their junction box housings resulting in damage to the CT wiring. In response, SQN installed tape on the bolted connections inside the CT junction box. On May 13, 2005, the

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first performance of the revised PM was conducted. The previous procedure required inspection of the generator protective electrical circuit connections. The revised PM specifically required opening and inspecting the junction boxes. The revised PM has a frequency of once every outage. All connections in the CT junction box were found to be in satisfactory condition. A section of conduit was removed and replaced with flex conduit to aid in isolating neutral CT junction boxes from vibration. Additionally, new aluminum supports were installed to stabilize conduits connected to the CT junction boxes. From 2005 to 2014, five performances of the inspection PM identified no abnormal conditions in the C-phase neutral CT junction boxes or cabling/connections. The most recent performance of the inspection PM was May 20, 2014 during the Unit 2 Cycle 19 (U2R19) refueling outage which identified the C-phase neutral bushing CT junction box as satisfactory.

On March 2, 2015 at 0645 EST, the Unit 2 reactor automatically tripped following a turbine trip due to an open C-phase neutral CT cable.

| Dates | Description |
|---|---|
| May 4, 1992 | New field cables with bolted connections were installed. |
| May 12, 2003 | PM revised to add inspection of the CT junction box and connections. |
| November 23, 2003 | SQN installed tape on the bolted connections inside the CT junction box in response to WBN issue. |
| May 13, 2005 | First performance of revised PM resulted in satisfactory condition of all connections in the CT junction box. |
| 2005-2014 | Five performances PM identified no abnormal conditions in the C-phase neutral CT junction boxes or cabling/connections. |
| May 20, 2014 | PM identified the C-phase neutral bushing CT junction box as satisfactory. |
| March 2, 2015 at 0645 EST | The Unit 2 reactor automatically tripped following a turbine trip due to an open C-phase neutral CT cable. |

D. Manufacturer and model number of each component that failed during the event:

There was a splice connection that failed on the cables [EIIS Code CBL] between the 287G differential relay and the main generator C-phase CT. This splice was connecting the field cable to the CT cable. The manufacturer of the CT wiring was Westinghouse.

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E. Other systems or secondary functions affected:

There were no other systems or functions affected by this event.

F. Method of discovery of each component or system failure or procedural error:

After Unit 2 automatically tripped, a continuity test was performed on the 287G CTs which showed that the C-phase had an open circuit. All CT junction boxes were then visually inspected and a broken splice connection was identified between the 287G differential relay and the C phase CT.

G. The failure mode, mechanism, and effect of each failed component, if known:

When the main generator C-phase neutral CT cable failed, the 287G differential relay actuated causing a turbine trip. The turbine trip caused the Unit 2 reactor trip.

H. Operator actions:

The operators entered Emergency Procedure E-0, Reactor Trip or Safety Injection and then transitioned from E-0 to Emergency Subprocedure ES-0.1, Reactor Trip Response. There were no complications or human performance issues associated with the trip response identified.

I. Automatic and manually initiated safety system responses:

Following the reactor trip, all plant safety systems responded as designed. All control rods fully inserted as required. Auxiliary feedwater automatically initiated from the feedwater isolation signal as expected.

## III. CAUSE OF THE EVENT

A. The cause of each component or system failure or personnel error, if known:

The direct cause of the cable failure was the combination of corrosion and periodic physical manipulation which resulted in ultimate failure of the C-phase neutral CT cable. The contributing cause of the event was liquid intrusion into the CT junction box.

B. The cause(s) and circumstances of each human performance related root cause:

The root cause of the event was an inadequate PM procedure which did not contain periodic inspections to identify potential failure mechanisms. Each unit's main generator CT junction boxes are opened and inspected every outage via a common PM task. Emphasis is placed on examining the CT junction box conduit connections. There are instructions to inspect connections for tightness, but there is no specific direction to perform an intrusive inspection which would have identified degradation under the tape of the CT bolted connection.

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## IV. ANALYSIS OF THE EVENT

SQN Unit 2 automatically tripped following a turbine trip due to actuation of the main generator 287G differential relay. The relay actuation was a result of a failure of the main generator C-phase neutral current transformer cable. A broken splice connection was identified between the 287G differential relay and the C-phase CT. In this reactor trip, all auxiliary feedwater (AFW) pumps, steam dump valves, and atmospheric relief valves were available. The plant transient response including reactor power, reactor coolant system (RCS) pressure, RCS secondary side pressure, RCS temperature, pressurizer level, and AFW flow remained within technical specification limits and was bounded by the Final Safety Analysis Report (FSAR). Containment pressure, temperature, and radiation were unaffected by this transient. Steam generator level experienced during this event were bounded by FSAR analysis. The plant responded as expected for the conditions of the trip.

The failed cable splice components were sent to TVA's Central Laboratories Services for analysis. Review of the failure analysis concluded that a large voltage potential developed when the cable initially became an open circuit of high resistance due to the electrical nature of CTs. This energy increased until the potential was discharged in the form of an electrical arc. The discharge of energy caused severe damage to the conductors and bolted connection.

The open circuit was caused by a combination of corrosion and periodic physical manipulation. The corrosion showed signs of both galvanic corrosion and corrosion from an outside source. Signs of liquid intrusion into the junction box were evident based off of photographic evidence and lab analysis of the failed connection. The source of the liquid intrusion could not be determined.

## V. ASSESSMENT OF SAFETY CONSEQUENCES

There were no safety consequences as a result of the event. All safety systems functioned as designed and no complications were experienced.

A. Availability of systems or components that could have performed the same function as the components and systems that failed during the event.

There were no other components that could have performed the same function as the main generator C-phase neutral CT cable that failed.

B. For events that occurred when the reactor was shut down, availability of systems or components needed to shutdown the reactor and maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident.

This event did not occur when the reactor was shut down. Safety-related systems that were needed to shut down the reactor, maintain safe shutdown conditions, remove residual heat or mitigate the consequences of an accident remained available throughout the event.

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C. For failure that rendered a train of safety system inoperable, an estimate of the elapsed time from the discovery of the failure until the train was returned to service.

There was no failure that rendered a train of a safety system inoperable.

## VI. CORRECTIVE ACTIONS

Corrective Actions are being managed by TVA's Corrective Action Program under PER 993743.

A. Immediate Corrective Actions:

- Replaced both C-phase neutral CTs (the CT for the SEL-300G relay and the CT for the 287G differential relay) and all associated field cables.
- Replaced B-phase neutral CT (specifically the CT which provides a signal to the voltage regulator) and all associated field cables.
- Replaced all associated field cables to A-phase neutral CT.

B. Corrective Actions to Prevent Recurrence or to reduce the probability of similar events occurring in the future.

Corrective Actions to Prevent Recurrence:

- Replace all Unit 1 and Unit 2 main generator CT bolted connections with solder filled splices, covered in Raychem to prevent water intrusion.

## VII. ADDITIONAL INFORMATION

A. Previous similar events at the same plant.

A review of previous reportable events for the past 3 years identified one event caused by inadequate PMs. LER 2-2012-001 involved an automatic reactor trip on loss of flow due to a reactor coolant pump trip. The root cause was determined to be a lack of guidance in the PM instructions for replacement of the ground fault relay that caused the trip, which had reached the end of its service life. In addition, LERs 1-2013-004-01, 1-2014-001-00, 1-2014-002-00, and 2-2014-002-00 involved inadequate procedures. LER 1-2013-004-01 involved a failure to comply with TSs for containment penetrations during fuel movement resulting from ineffective procedures. LER 1-2014-001-00 involved a never performed TS surveillance for the Common Spare Component Cooling System (CCS) Pump due to lack of procedural guidance. LER 1-2014-002-00 involved inadequate revision to a surveillance instruction following a Technical Specification change. LER 2-2014-002-00 involved procedures not specifying an accurate drawing for reassembling the containment vacuum relief valve and also an inadequate operating instruction for reestablishing containment integrity.

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B. Additional information.

None.

C. Safety System Functional Failure Consideration.

This event did not result in a safety system functional failure in accordance with 10 CFR 50.73(a)(2)(v).

D. Scrams with Complications Considerations.

This condition did not result in an unplanned scram with complications.

VIII. COMMITMENTS

None